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Wang et al.

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(54) **COOPERATIVE CAM PHASER AND AIR THROTTLE CONTROL**

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See application file for complete search history.

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(56) **References Cited**

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U.S. PATENT DOCUMENTS

6,062,026	A	5/2000	Woolenweber
6,311,493	B1	11/2001	Kurihara
6,615,129	B2	9/2003	Kabasin
6,728,625	B2 *	4/2004	Strubhar F02D 29/06 123/480

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7,000,393	B1	2/2006	Wood
7,305,950	B1	12/2007	Sinnamon
7,380,447	B2	6/2008	Rollinger et al.

(Continued)

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FOREIGN PATENT DOCUMENTS

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EP	2489851	8/2012
GB	1299784	12/1972

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(51) **Int. Cl.**

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(57) **ABSTRACT**

Methods and apparatus relate to air handling for an internal combustion engine system, particularly utilizing premixed air and fuel. The engine system includes an intake air throttle (IAT) having a position set in response to the engine speed and a variable valve timing module having an intake valve timing set in response to the engine load. The variable valve timing module may be a cam phaser having a position at or between full retard and full advance positions. The engine system may operate in a transient mode or a fuel efficiency mode. The IAT position is adjusted in response to an engine speed error value or set at full throttle. The cam phaser position is adjusted in response to a pressure difference across the IAT, the engine speed, or is set to a limit position.

(52) **U.S. Cl.**

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13 Claims, 9 Drawing Sheets

